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A multiple intelligences theory-based 3D virtual lab environment for digital systems teaching.

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Abstract

This paper describes a 3D virtual lab environment that was developed using OpenSim software integrated into Moodle. Virtuald software tool was used to provide pedagogical support to the lab by enabling to create online texts and delivering them to the students. The courses taught in this virtual lab are methodologically in conformity to theory of multiple intelligences. Some results are presented.

Keywords: 3D Virtual Environments, Learning Management Systems, OpenSim, Moodle.

1 Introduction

Virtual laboratories are simulation environments that allow students to participate in experiments in predefined conditions. The laboratories can be reached through any computer network.

The development of virtual laboratories is an interesting alternative to professional education as well as career development in several areas of knowledge. Among the technologies that can be used for the development of such kind of labs are virtual 3D environments also known as 3D worlds.

Virtual 3D worlds are interactive environments capable of simulating some real world characteristics such as gravity, topography and movement, real-time actions and interpersonal communication.

The use of virtual 3D environments in education has been subject of several researchers such as those by Ritzema and Harris (Ritzema and Harris, 2008), Baldi and Lopes (Baldi and Lopes, 2012), Ridgewell *et al.* (Ridgewell *et al.*, 2011). However, there are some open questions in particular those regarding teaching and assessment methodologies that should be used within these environments.

A pedagogical option is the theory of multiple intelligences initially proposed by Howard Gardner (Gardner, 1995). The merging of virtual labs technology with the theory proposed by Gardner can result in an excellent way of supporting activities previously developed in the classroom. During the research reported in the present paper the development of a virtual 3D laboratory environment using the OpenSim software, called Virtual Laboratory of digital systems (Labvirsd).

In this work we combine 3D virtual world technologies and Gardner's multiple intelligences to stimulate students through the use of some particular intelligences, remarkably those initially proposed by Gardner, namely: the logical-mathematical, linguistic, spacial, bodily-kinesthetic, interpersonal, intrapersonal, musical.

This paper is organized as follows: in section 2 there is an overview of virtual laboratories and of learning management systems; in section 3 virtual worlds and Sloodle (the plugin used to integrate virtual lab and Moodle) are addressed; in section 4 the theory of multiple intelligences is presented and some application examples are visited; in section 5 the state-of-the-art of virtual laboratories in 3D environments is discussed; in section 6 the virtual laboratory development process is described; in section 7 the didactic approach implemented in the 3D environment is introduced; in section 8 some results are presented; and in section 9 the paper is concluded with some final remarks.

1 Virtual Laboratory

Virtual laboratories are computer simulation-based environments used to interactively design and conduct controlled experiments. The results of such experiments depend on input data previously defined by the user (Gomes and Bogosyan, 2009).

These simulation environments provide a space for experimentation in which there are no safety concerns regarding real equipments. As they can be accessed either in local workstations as at distance through the internet they are considered remote environments. The functionality of virtual labs is often improved with online lectures and step-by-step instructions to deal with the lab work (Gomes and Bogosyan, 2009).

Access to such labs can be controlled using a Learning Management System (LMS). Besides access control, an LMS can be used to monitor and register the students activities while they are within the environment. A widely used LMS system is the Modular Object-Oriented Dynamic Learning Environment (*Moodle*).

Moodle is a free and open source platform developed by Martin Dougiamas that enables to monitor student progression either in classroom courses or in semipresential ones (Kumar, Gankotiya and Dutta, 2011), (Dougiamas, 2013) .

1.1 The Metaverses

3D virtual worlds or metaverses are immersion environments allow the simulation of some real environment features such as sound, and gravity. Some of the most well known virtual worlds are *Second Life*, *Active Worlds*, *There* and *OpenSim*.

OpenSim is an open source software kept by a community of developers. It basically has the same features as *Second Life* but it also presents some limitations as compared to *Second Life* (Overte

Foundation, 2013). However, being open source and not imposing limits to objects or regions development makes it a good choice for educational purposes.

Second Life allows free subscription and interaction of users. Nevertheless, it restricts the permanent objects and groups development, and many actions that have to be taken in this environment are charged. This means that in some educational situations the use of this software is narrowed.

Anyway, *OpenSim* and *Second Life* are compatible to one another as well as both are compatible with the communication protocols of other platforms. Thus, *OpenSim* is used by lots of universities and several large companies.

The integration of 3D virtual environment to Moodle is accomplished through Simulation Linked Object Oriented Dynamic Learning (*Sloodle*) plugin. The goal of *Sloodle* is to make available to the users diverse tools to enable the accomplishment of some tasks within the virtual environment, registering such actions in Moodle (Konstantinidis *et al.*, 2010), (Yasar and Adiguzel, 2010).

1.2 *Sloodle*'s Functionalities

Sloodle presents the following functionalities (Konstantinidis *et al.*, 2010):

- Web-intercom: This functionality allows the user take part in chats within the 3D environment. The records of such chats can be viewed both in the virtual environment and in *Moodle* server. These records are stored in *Moodle*'s database.
- Registration booth: This functionality allows to relate student's avatars to their corresponding *Moodle*'s accounts. It is required because students frequently have different names for their accounts and their avatars what can pose some problems when recording their activities.
- MetaGloss: This functionality allows the students' avatars to access the glossary created for the course in *Moodle*.
- Quiz tool and 3D Drop Box: This functionality allows the students to execute tasks involving the creation of objects in the virtual environment. The objects created are then transferred to *Moodle* similarly to the way a file is uploaded.
- Multi-function Toolbar: This functionality allows the user activate the blog development function within the virtual environment. Such blogs can be viewed both in the virtual environment and in *Moodle*.
- Presenter: This functionality allow the users to post in the virtual environment, slideshows or videos that can be viewed or downloaded from the *Moodle* server.
- QuizChair: This functionality allows the students to answer to multiple choice questions prepared in *Moodle*, which also stores the answers.

As *Sloodle* is an open source project and constantly under development, other functions are likely to be implemented and made available later.

2 The Theory of Multiple Intelligences

The theory of multiple intelligences developed by Howard Gardner aimed at presenting a new concept of intelligence, which so far was restricted to IQ (Intelligence Quotient) tests created in 1920 by Alfred Binet (Binet, 2004).

According to Gardner intelligence is the capability to solve problems as well as to create products that are meaningful to one or more cultural environments. Furthermore, it is a combination between genetic inheritance and environmental influences (Gardner, 1998).

Gardner suggests the existence of nine intelligences, namely: linguistic, musical, logical-mathematical, spatial, bodily-kinesthetic, intrapersonal, interpersonal, naturalist, and existential (Gardner, 1999), (Gardner, 1998).

2.1 Applications of the Theory of Multiple Intelligences

Qingsheng (Qingsheng *et al.*, 2010), formulated a multimedia and network environment, based on the Theory of Multiple Intelligences by developing a model called "Multimedia Intelligence Course".

The use of multimedia technologies provides the student an environment where the process of knowledge construction is favored by the presence of graphics, sounds and images, and in particular the use of the internet providing opportunities for students to exchange experiences (Qingsheng *et al.*, 2010).

The model proposed in the work presented in this paper aims at stimulating students curiosity, while motivating their choices emphasizing their personal practical experiences. The main idea for the use of multimedia technologies is the sharing of experiences among students, in contrast to the traditional method in which the student is evaluated individually.

The implementation of the proposal developed by Qingsheng *et al.* (Qingsheng *et al.*, 2010), took place in four phases, namely: classroom teaching guided by multiple intelligences; achieve intelligent class teaching; integration of smart teachers and intelligent medias; and cultivating students the abilities of innovation and comprehensiveness.

Qingsheng *et al.* (Qingsheng *et al.*, 2010) reported that during their research a package consisting of a set of programs developed with the aim of stimulating multiple intelligences in students was implemented. The software packages are: E Media Classroom Packages, Net Vision Packages. They resemble other LMS like *Moodle*.

Qingsheng *et al.* (Qingsheng *et al.*, 2010) claim that stimulation of multiple intelligences is performed with the aid of this software suite, but do not describe in their paper how as the tests were conducted, nor even describe them.

Ali and Zaman (Ali and Zaman, 2008), developed a software called MI-Mathematics. The software based on the theory of multiple intelligences is comprised of five modules and aims to usability evaluation of multimedia learning materials in the area of mathematics, specifically for teaching trigonometry.

The evaluation of software is based on five parameters, namely: efficacy; learning capability; ease of use; flexibility; and user attitude.

MI-Mathematics is a multimedia courseware consisting of five modules working independently, namely: introduction; review; processing; enrichment; and test. The goal is to motivate students to learn mathematics using their main intelligence.

MI-Mathematics is a software whose modules are tutorials using three different methodologies to accommodate three different types of intelligences, as follows: linguistic intelligence, logical-mathematical intelligence and visual spatial intelligence.

The so called MI-Mathematics instruction model has six elements, specifically: multiple types of intelligences, learning objectives, learning theories, approaches, learning strategies and interactivity.

The educational content of the MI-Mathematics software consists of five modules in each of which student performs a knowledge and skill test that determines whether or not the module can be used. The elements that comprise the system are: introduction, revision, exploration, explanation, example and exercise.

A test of the software was conducted with 59 students from a secondary school in Selangor, Malaysia. The efficacy, the ease of learning, the flexibility of the software, the usability, and user

attitude with respect to the course material were evaluated. The students were split into two groups, respectively with 30 and 29 persons. Both groups were assigned the same set of tasks. However, the most vivid intelligences of the students in the first group were taken into consideration, while students of the second group took the test without having the kind of their intelligences assessed. Ali and Zaman concluded that in this phase the results are quite similar, and no significant differences were found between the two groups.

Ease of learning — in this phase the students were evaluated based on five items: ease of understanding, background color of the screen, ease of use, level of acceptance of the material, and whether the material helps to learn about trigonometry. According to the researchers all items showed a positive average in the assessment reported by the students. Moreover, according to Ali and Zaman on the average all students stated that the software is easy to use, is flexible, and make the classes more enjoyable, among other things.

3 Virtual Laboratories and Metaverse: state of the art

The development of virtual teaching aids using 3D environments has been subject of research in many different areas of knowledge. The application of this technology allows one to create environments such as virtual laboratories restricted to only one virtual space or even a full campus.

Guo *et al.* 2009 (Guo *et al.*, 2009) developed the campus as well as the virtual labs of Jiliang University, China. To accomplish such a task they combined the physical campus network with the virtual environment. The system uses the blended learning technique (Arbaugh and Hwang, 2013). Blended Learning is a methodology that uses the internet to transfer most of the required knowledge at distance, but requires classroom situations to combine resources available either in the real or in the virtual environments. The basic idea of the virtual campus based experiment is to combine virtual labs functions with those stored in the real campus network server.

The theoretical model of the net developed by Guo *et al.* in a virtual environment comprises two main parts that can be further divided into other five independent functional layers, similar to the OSI (International Standards Organization) reference model (Tanenbaum, 2012). The goal was to provide the students with a virtual environment similar to the physical one in which the students could run experiments based on the knowledge acquired in the discipline of networking.

Tarouco *et al.* (Tarouco *et al.*, 2013) developed a virtual lab using *OpenSim*. The goal of their software is to help teaching calculus for engineering curricula. The laboratory was developed in four stages that begins with the choice of theoretical calculation for teaching methods, and goes through the development of learning objects to the virtual environment.

Tests with Taroucos *et al.*'s environment were divided into two parts. Initially the students used the *E₂D* environment, which is similar to *Moodle*. Then the lectures developed with *E₂D* was reproduced in the virtual world. According to the authors the test results were satisfactory showing the feasibility of using this technology in teaching.

Rico *et al.* (Rico *et al.*, 2012), developed an architecture comprising a set of virtual laboratories addressing biotechnology, chemistry, and electronics for the operation of a nuclear plant. Each lab represents a module within the environment, and is operated according to the knowledge level of each user.

The execution of tasks is coordinated by a "tutor guide". The "tutor guide" is characterized by a set of instructions pre-defined by the developer of the environment. These instructions are triggered primarily when an action to be performed requires it to run a previous action. An example is the action of filling a glass with water, if the user is not with the glass in hand the tap is not opened.

Rico *et al.* (Rico *et al.*, 2012) claim that the environment is easy to configure and that much of the structure was developed using the software blender and then imported into *OpenSim*. Their paper does not mention eventual application of the reported architecture.

4 Development of the Laboratory

In the development of 3D virtual environment are associated with information and communication technologies (ICTs) with teaching methodologies proposed by Gardner and Piaget seeking a better assimilation content transmitted to the students within the Labvirsd.

The virtual laboratory presented in this paper is being developed using a 2 GHz dual core Pentium computer with 2 GB of RAM, and video card NVIDIA GeForce 9500 GT.

OpenSim was configured in stand-alone mode as the 3D lab environment has been restricted to UNESP (Sao Paulo State University) users in this phase. This restriction has been due to the fact that during this first phase of the development process our goal has been to assess some features and the usefulness of the environment as an educational tool within the scope of the computer science course offered by UNESP, at Rio Preto campus.

In the following phase the access to the lab will be open to any student regularly enrolled in some university course. In this second phase student registration is going to be made from a list of students generated by UNESP's academic management system.

The initial structure representing a space for theoretical activities is presented in Figure 1.

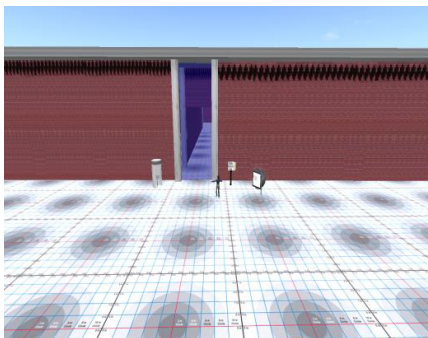


Figure 1 - *Sloodle* access tokens



Figure 2 - Classroom 1

The laboratory has 5 environments among which there are classrooms where theoretical contents are taught via chat with voice and text, as well as environments for practical classes and assessments. All environments can be configured according to the profile of the activity to be performed.

The Figure 2 shows the room 1 where objects of apprenticeship called chair quiz scoreboard vending machine and chat are disponibilizados students. Such objects provide students develop activities that involve the resolution of issues with content geared to digital systems, whose correct answers can be displayed on the score board.

Students can also interact with each other and with the teacher via chat, besides having access to available through vending machine 3D objects.

Moodle has been configured to run *Sloodle* plugin. *Sloodle* is connected to the 3D virtual environment through a resource called *Sloodle Controller* (Nunes and Voss, 2013) linked to a course that must be created in *Moodle* platform. This feature enables the features previously described in Section 3.

The activities initially available in this environment are activated by the touch of the student's avatar in the virtual object. The activities available in this first phase are the chat, the glossary of

terms that can be consulted by the student, the chair of tests where the student is assessed through multiple-choice questions and *Virtualab* tool that will be described in Section 4.1.

4.1 Virtualab Tool

Virtualab is one of the tools used in this project. It is a module consisting of a web page, and aiming to provide educational support to the laboratory, by making texts, images and videos available on line. These handouts are inserted by the teacher and can be consulted by students.

The materials are made available by the teacher through an administrative area (called blackboard) where it is possible to create, edit or remove topics. The blackboard area has a text editor that the teacher can use to input the class material.

With this tool, students are able to read information about all the topics covered by teachers in regular classes. The materials can be viewed within the virtual lab through the browser installed on the student's computer.

5 Didactic proposal

The didactic proposal of this work involves teaching a discipline of digital systems, through the implementation of activities within the virtual environment, to stimulate the seven intelligences originally defined by Gardner. The content to be covered in the course will be (Costa Neto, 2009):

- Introduction to discrete and continuous systems;
- Definition of binary digital systems;
- Binary signal representation;
- State diagrams;
- Logic operations;
- Fundamental logic gates (AND, OR, NOT).

Given the integration of the virtual environment with *Moodle* platform the tasks can be performed with the use of objects available in the 3D environment. When the use of such objects is not possible, the activity can be performed within the platform.

Each intelligence is associated with the execution of one or more activities, so the linguistic intelligence is stimulated by student participation in forums, chats as well as the reading and interpretation of assessments exercises.

The logical-mathematical intelligence is stimulated by building circuits within the virtual environment. The construction of these objects also aims to stimulate the bodily-kinesthetic intelligence since it requires the academic ability to properly use the mouse.

The musical intelligence is stimulated through the use of video, voice chat and other forms of sounds that can be imported to the environment according to the needs of each task.

The visual spatial intelligence, and the bodily-kinesthetic are also stimulated by conducting activities that involve the creation of objects in the virtual environment, since for performing these activities the student must have a visual perception to size and position objects. Another factor that helps in stimulating such intelligence is the fact that the user has to move around within the environment, which can be done in three ways: walking, running or flying.

The interpersonal and intrapersonal intelligences are jointly stimulated by activities that should be conducted in groups, available both in the virtual environment and in the *Moodle* platform.

6 Results

The laboratory has been tested with computer science students at UNESP's Rio Preto campus. Students that took part in the test are enrolled between the second and eighth semesters of this course. The trial lesson lasted approximately 30 minutes. Besides participating in some activities the attendees were asked to answer a questionnaire whose data is presented in Section 6.1.

6.1 Results analysis

An online questionnaire containing 6 questions divided into 2 sets, one addressing the use of the learning environment and the other the ease of learning resulting from the use of different technologies. The graphs in Figures 3 and 4 show the results.

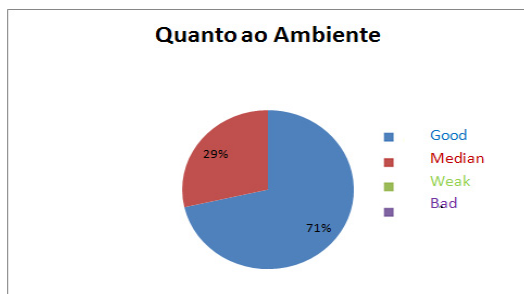


Figure 3 - Result of the first set of questions

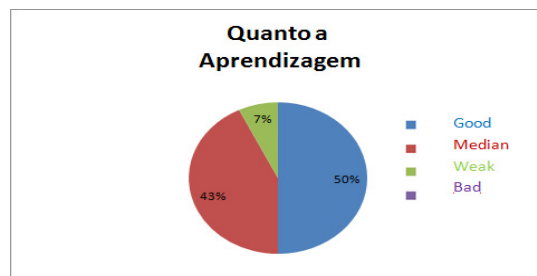


Figure 4 - Result of the second set of questions

The results displayed in Figure 3 show that the acceptance of students regarding the use of the laboratory was mostly good, which leads us to conclude that in the case of the structural part of the environment, locomotion and activities are generally satisfactory. Those answers indicating lower ranking of the environment are due to some adjustments that are scheduled to be implemented in the following phase of this research.

Figure 4 presents how easy is it to learn using the 3D environment. Students are divided over the use of 3D environment for teaching, maybe this is due to the initial phase of research where not all pedagogical tools have been implemented in the environment.

7 Conclusions

The development of virtual laboratories in 3D virtual worlds presents itself as a resource for teaching in engineering and computer science. At this stage of the research we sought to highlight ways to use this technology as a teaching tool to be used for the transfer of knowledge to students of both areas.

The activities developed so far, which involved the process of installation, configuration and development of initial structures, as well as the use by students, were conducted without major problems.

The collected data will be the basis for the next phase of the laboratory development. Generally they point to a deepening of the use of the environment with activities directed to online games since students expressed enthusiasm by the possibility of using the laboratory like a game.

Among the activities to be performed in a later phase of the project there is the implementation of new tasks for the students, as well as developing more applications for the Virtualab tool, in particular one that allows the minimization of Boolean functions using Karnaugh maps.

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